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Frank et al.

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[54] **METHODS AND APPARATUS FOR SCRUBBING THIN, FRAGILE SLICES OF MATERIAL**

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[52] **U.S. Cl.** ..... **15/21 D**, 51/89

[51] **Int. Cl.** **A46b 13/04**

[58] **Field of Search** ..... 15/21 R, 21 A, 21 B, 15/21 C, 21 D, 21 E, 88, 97 R; 134/6; 51/89

[56] **References Cited**

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[57] **ABSTRACT**

Simultaneously, both sides of a thin, fragile slice of brittle material, such as single-crystal silicon, are scrubbed. The slices are loaded, one at a time, into a rotatable disc having pockets formed in the periphery thereof. The disc conveys the slices between two opposed counter-rotatable brushes within a detergent spray. After passing the rotatable brushes, the slices drop from the disc and float through the detergent bath to a container positioned below the disc.

10 Claims, 2 Drawing Figures

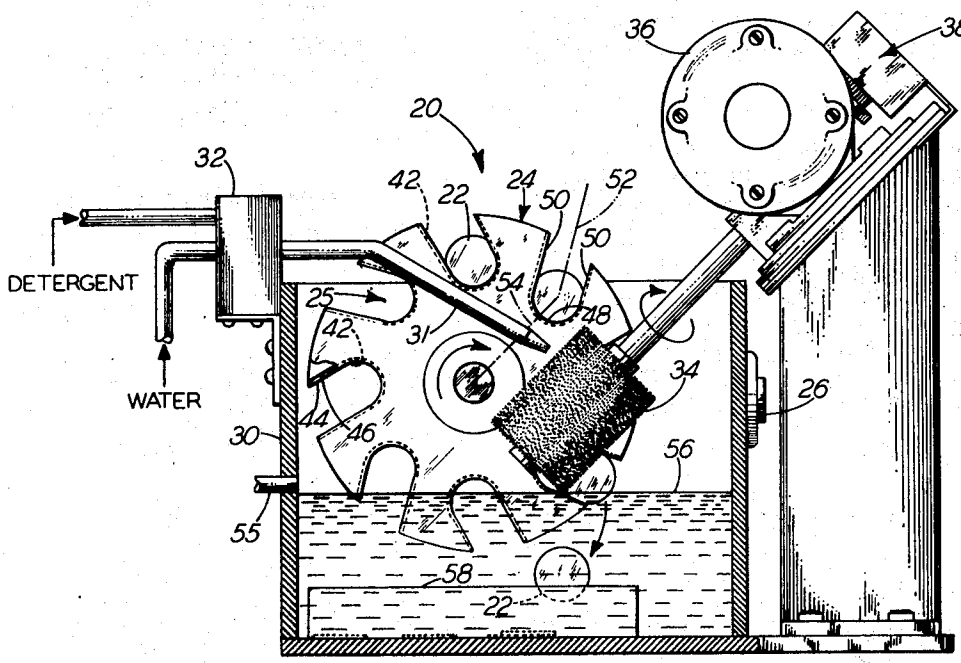
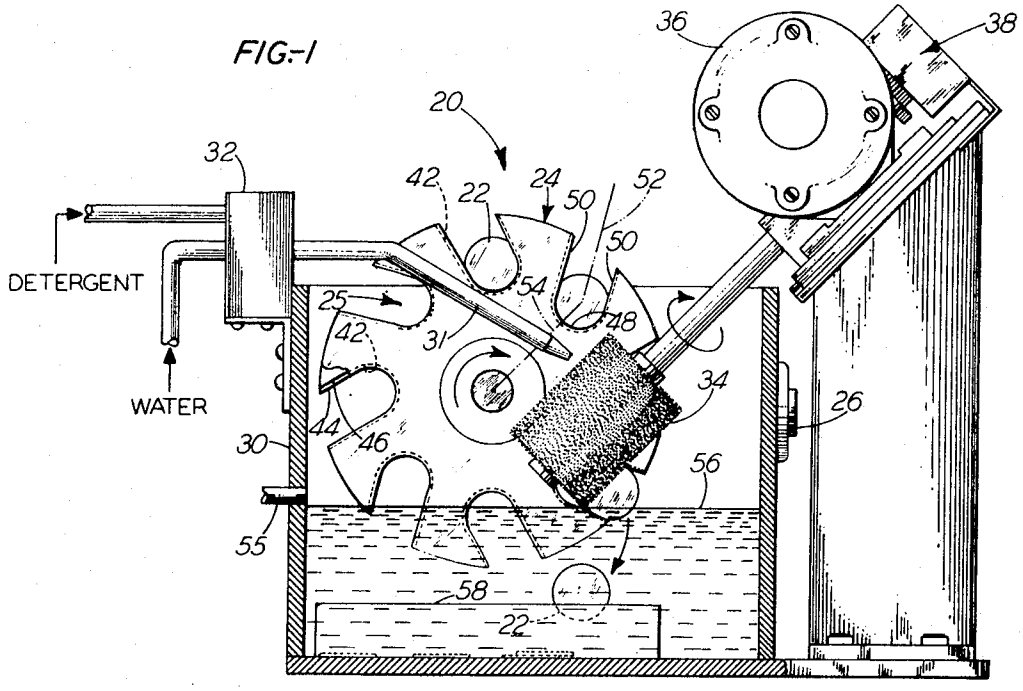


FIG:-1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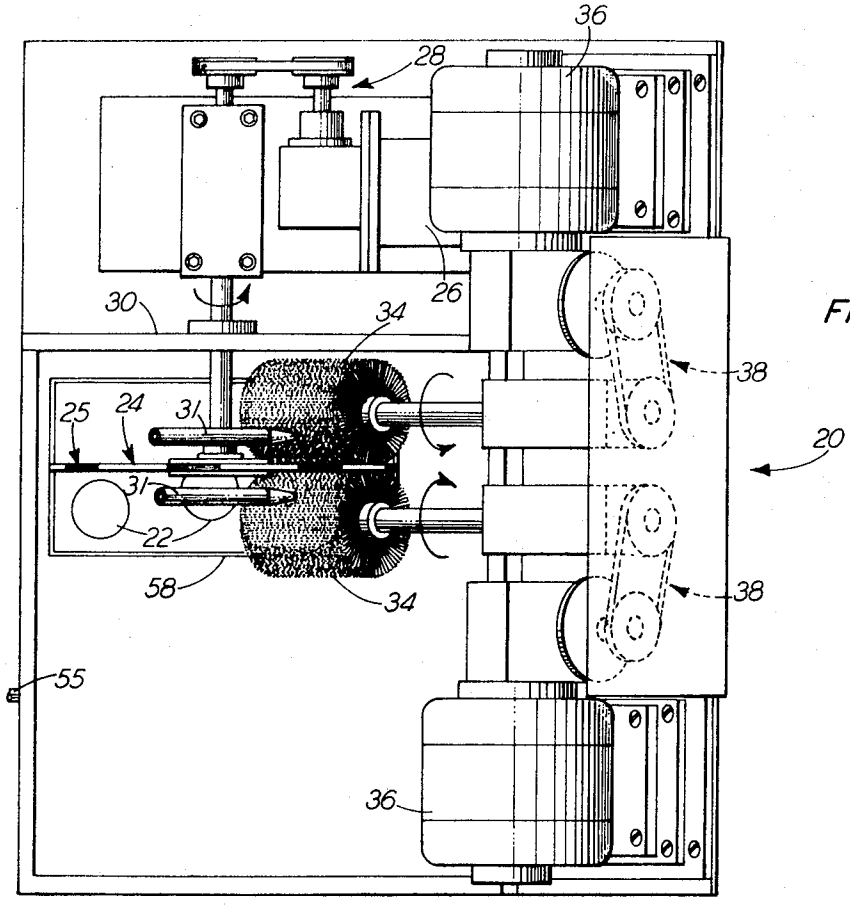
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FIG:-2

METHODS AND APPARATUS FOR SCRUBBING THIN, FRAGILE SLICES OF MATERIAL

This is a division, of application Ser. No. 73,473 filed Sept. 18, 1970, now U.S. Pat. No. 3,664,872.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to apparatus for scrubbing thin, fragile slices of material. More particularly, the invention relates to apparatus wherein both sides of the thin slices are scrubbed simultaneously and wherein handling of the slices is minimized.

2. Description of the Prior Art

In the field of semiconductor manufacturing, a long standing problem has been elimination of manual processing steps and introduction of automatic machinery for performing these steps. One area which consumes a significant amount of processing time is cleaning of semiconductor material.

Semiconductor manufacturing typically starts with growing single crystal ingots and then cutting the ingots into thin slices of single crystal material. Some typical materials are silicon and germanium. Current semiconductor technology demands that the slices be quite thin, in the order of magnitude of 10 to 20 thousandths of an inch.

The thin slices, having been cut from a rod of bulk material must have residual particulate matter and cutting lubricants removed from their surfaces. Scrubbing is usually necessary. This scrubbing has been performed manually by placing each individual slice on a scrubbing pad and then brushing each side of the slices manually with a detergent solution. The operation has been performed manually because of the extremely fragile nature of the thin silicon or germanium slices.

Some mechanized apparatus has been available for scrubbing semiconductor slices but it can only scrub one side of a slice at a time. The slices must be initially loaded into such apparatus then unloaded, turned over and reloaded in order that both sides of a slice can be scrubbed. Such multiple handling has left a situation in which it is still more desirable to manually scrub devices than to use mechanized apparatus in the existing form.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide a system for scrubbing thin, fragile slices of material wherein both sides of a slice are scrubbed simultaneously.

It is a further object of the invention to provide a system of scrubbing slices in which the handling of such slices is minimized.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and features of the present invention will be more readily understood from the following detailed description of specific embodiments thereof when read in conjunction with the appended drawings in which:

FIG. 1 is an elevational view of an inventive scrubbing machine with portions thereof removed for purposes of clarity; and

FIG. 2 is a plan view of the machine of FIG. 1.

DETAILED DESCRIPTION

Illustratively, the invention will be described in connection with scrubbing slices of single crystal silicon material having a thickness of 10 to 20 thousandths of an inch and having a diameter of 2 inches. However, it is to be understood that the apparatus will function quite successfully in the scrubbing of various types of thin, fragile slices of material having a range of dimensions quite diverse from those set forth in the example.

FIGS. 1 and 2 show a general arrangement of a scrubbing machine, designated generally by the numeral **20.** Thin, fragile slices **22** of single crystal silicon material are deposited into a rotatable slice-conveying disc, designated generally by the numeral **24.** The slices are loaded into slice holding pockets, designated generally by the numeral **25,** one at a time, as the disc **24** continuously rotates. Rotation of the disc **24** is accomplished by a motor **26** and drive train, designated generally by the numeral **28.**

The disc **24** rotates within a fluid-tight container **30.** Both sides of the disc **24** are continuously sprayed with a water detergent solution comprised for example of 1 percent Igepal available from General Aniline and Film Corp., Grasselli, New Jersey. The solution emerges from jets **31** which are fed by a conventional metering unit **32** and a source of water.

Two rotatable brushes **34** are engaged with opposite sides of a portion of the disc **24** adjacent the spray impingement area. The brushes are driven by motors **36** and drive trains, designated generally by the numeral **38.** The brushes can be, for example, 5 mil nylon, full-brush bristled type 2024–T4 aluminum core and shank, brush No. 38454 available from M. W. Jenkins Sons, Inc. Cedar Grove, New Jersey.

In an alternate arrangement, now shown, the container **30** can be operated as a holding tank with the water-detergent solution completely covering the brushes **34.**

The slices **22** are held within the disc **24** in slice holding pockets **25.** The slice holding pockets **25** are advantageously formed in the disc **24,** fabricating the disc from three sheets of metal, an inner sheet **42** having a configuration generally as shown by the dotted line in FIG. **1** and two outer sheets **44** having configurations generally as shown by the solid lines in FIG. **1.** The inner sheet **42** is made thicker than the slice **22** so that when the outer sheets **44** are spot welded to the inner sheet, a groove **46** is formed into which the outer periphery of one of the slices **22** can easily slide. For example, to accommodate a slice 0.015 inch thick the inner sheet should be approximately 0.030 inch thick.

Each of the pockets **25** has a composite shape made up of a semicircular portion **48** and a parallel-sided slot portion **50** connecting the semicircular portion with the outer periphery of the disc **24.** A central axis **52** of the slot portion **50** is oriented at an angle of 30° with respect to a radial line **54** connecting the center of the disc **24** with the center of the semicircular portion **48.**

The angular arrangement of the slot portion **50** has utility during discharge of the slice **22** from the disc **24.** Because the slices **22** are loosely held within their respective pockets **25,** they fall from their pockets when the axis of the slot portion **50** becomes oriented downwardly during rotation of the disc **24.** As each of the pockets **40** is oriented downwardly and emerges beyond the brushes **34,** the slice **22** within the pocket **24** begins to roll out.

The container **30** is provided with an overflow valve **55** positioned to maintain a cushioning bath **56** of the

water-detergent solution at a level just above the point where the slice **22** begins to roll from their respective pockets **24.** The slices **22** are thus carried into the bath **56** before they emerge from their pockets **24.** If the level of the bath **56** were lower, the slices **22** would fall through air prior to reaching the surface of the bath. This might result in some of the slices **22** striking the surface of the bath **56** with their diametrical surfaces, and such a situation would result in the slices floating on the surface of the bath due to surface tension. Floating of a slice **22** would permit drying of one side of the slice resulting in undesirable marking of the exposing surface.

When each of the slices **22** enters the bath **56,** there is a cushioning effect exerted b the bath and each slice is gently dropped into a slice container **58** positioned below the disc **24.** The orientation of the slot axis **52** with respect to the radial lines **54** contributes to a gentle rolling action of each of the slices **22** as they are discharged from the disc **24.** This is very desirable because of the extremely fragile nature of the slices **22.** As the slices **22** gently roll from their respective pockets **25** and float down to the container **58** under the cushioning effect of the bath **56,** there is very little probability of breakage.

In order to take advantage of the novel technique of handling the slices **22** within the loosely fitting pockets **25,** it is necessary to drive the brushes **34** in such a way that they tend to force the slices inwardly of the disc **24.** This is accomplished by rotating each brush in opposite directions as shown by the arrows on FIG. **2.**

The brushes **34** are arranged so that both sides of one of the slices **22** are contacted simultaneously. Thus, each side of the slice **22** is subjected to substantially the same lateral force by each of the brushes **34** and, as a result, substantially no tendency to bend or break the slice develops. In other words, the slices **22** are subjected to substantially pure compressive force components and virtually no bending force components enter into the scrubbing activity. Thin silicon slices are, of course, highly intolerant of bending and use of an arrangement other than opposed brushes would require full support across the surface of the slice. It is only the opposed brush arrangement which permits simultaneous scrubbing of both sides of the slices **22** and the very desirable reduction in occasions that each individual slice must be handled. The motors **28** and **36** are provided with controls by which their rotatable speed may be varied. It is desirable to be able to vary the speed of rotation of the disc **24** in order to be able to synchronize the loading of the machine **20** with the disc rotation. Also, the rate of rotation of the disc **24** determines the length of time that one of the slices **22** will be subjected to the scrubbing action of the brushes **34.** It is, of course, desirable to have the flexibility of being able to adjust the scrubbing time in order to compensate for such variations as different compositions of cutting lubricants and particulate contaminates which are to be removed from the surface of the slice.

It has been found that optimum scrubbing conditions are achieved with the brushes **34** of the type set out in the preceding example when they are rotated at a speed of 110–150 rpm.

During scrubbing of silicon slices which are 0.013 inch thick it has been found that a brush speed of 110 to 150 rpm provides optimum scrubbing where brushes of the type mentioned in the preceding example are used and where the center-to-center spacing of the brushes would provide for approximately one-quarter inch overlap of the bristles.

Although certain embodiments of the invention have been shown in the drawings and described in the specification, it is to be understood that the invention is not limited thereto, is capable of modification and can be arranged without departing from the spirit and scope of the invention.

What is claimed is:

1. Apparatus for scrubbing slices of material, which comprises:

a substantially planar slice-conveying disc, the disc being rotatable about an axis, the disc having a thickness greater than the slices to be scrubbed, and having slice-holding pockets formed about the periphery thereof each of said pockets being formed of a slotted aperture extending through the thickness of the disc and open to the periphery of the disc, the aperture being at least partially bounded by a groove adapted to engage a portion of the periphery of the slice when the slice is substantially coplanar to the disc and within the aperture so that a major portion of both sides of the slice are exposed within the aperture;

opposed rotatable brushes for engaging the exposed portions on opposite sides of the disc; and

means for rotating the disc about its axis to pass successive ones of the slices between the opposed brushes whereby the portions of the slices exposed within the apertures are scrubbed.

2. Apparatus for scrubbing fragile slices of material, which comprises:

a substantially planar disc rotatable with the plane of the disc oriented vertically, the disc having pockets formed into the periphery thereof for loosely holding the slices when the pockets are oriented in an upward position by the rotation of the disc and for discharging the slices when the pockets are oriented in a downward position by the rotation of the disc;

a pair of opposed brushed positioned to engage both sides of the disc so that upon rotation of the disc, the slices held within the upwardly position pockets pass between and are scrubbed by said brushes; and

means for cushioning the slices as they are discharged from downwardly positioned pockets to reduce breakage of the slices.

3. The apparatus of claim **2** which further comprises means for spraying a water detergent solution into the area of engagement of the brushes with the disc.

4. The apparatus of claim **2** wherein the brushes rotate in opposite directions with each brush rotating in a direction which tends to force the engaged slice inwardly of the disc, thus maintaining the slice within its respective pocket during brush engagement.

5. The apparatus of claim **2** which further comprises:

a fluid-tight container adapted to surround at least a portion of the rotatable disc; and

means to maintain a fluid level in the container sufficiently high to cover at least a portion of the disc thereby creating a fluid bath as a cushion for fragile slices dropping out of their respective pockets.

6. The apparatus of claim **2** wherein the slice-conveying disc has a thickness greater than the slices to be scrubbed, and the slice-holding pockets about the

periphery thereof are formed of a slotted aperture extending through the thickness of the disc and open to the periphery of the disc, the aperture being at least partially bounded by a groove adapted to engage a portion of the periphery of the slice when the slice is substantially coplanar to the disc and within the aperture so that a major portion of both sides of the slice are exposed within the aperture.

7. The apparatus of claim **6** wherein the aperture of the pocket is comprised of a semi-circular portion and a parallel sided slot connecting the semi-circular portion with the outer periphery of the disc, the slot having a central axis oriented at an acute angle with respect to a radial line connecting the center of the disc and the center of the semi-circular portion said orientation being in a direction opposite the direction of rotation of the disc whereby slices dropping from the disc are cushioned more effectively.

8. The apparatus of claim **7** wherein the acute angle between the slot axis and the radial line is 30°.

9. The apparatus of claim **2,** wherein the pockets are arranged at an angle with respect to the radius of the disc and slices are discharged by being rolled from the pockets.

10. The apparatus of claim **2,** wherein the cushioning means is a bath of water and detergent, and the bath is sprayed on the slices and the disc during rotation.

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